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A New Snake of the Genus *Agkistrodon* (Serpentes: Viperidae) from Tsushima Island, Nagasaki Prefecture, Japan

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Abstract: Specimens of the mamushi (genus *Agkistrodon*) from Tsushima Island were examined and compared with congeners from the mainland of Japan, China, and South Korea. The Tsushima specimens collectively differed from these congeners in several characters, and thus are described as a new species, *A. tsushimaensis*. A brief taxonomic key to the *Agkistrodon blomhoffii* complex is also provided.

Key words: Tsushima Island; Viperidae; *Agkistrodon*; *A. tsushimaensis* sp. nov.; Taxonomy

The population of *Agkistrodon* snakes of Tsushima Island, Nagasaki Prefecture, Japan, has hitherto been considered to be *A. blomhoffii blomhoffii* (Boulenger, 1896; Koba, 1955; Maki, 1931; Mori, 1929; Stejneger, 1907). Goris (1965) and Hashimoto and Toriba (1983) compared specimens from Tsushima Island with those from the mainland of Japan, and recognized unique features in dorsal pattern and ventral coloration of the former. On the basis of allozyme data, Paik et al. (1991) argued that the Tsushima population of *Agkistrodon* is geneticall ly closely related to *A. blomhoffii* and *A. ussuriensis*, but is differentiated from both of these species. These findings have suggested the necessity for reconsideration of the taxonomic status of the *Agkistrodon* population on Tsushima Island.

In 10–12 July 1986 and 28–30 July 1987, we surveyed Tsushima Island with other members of the Yomeishu Seizo Co., Ltd (YMS) Research Team (Fig. 1), and collected a total of 32 *Agkistrodon* specimens (14 males and 18 females). Examination of these specimens confirmed the characteristic differences in coloration of the Tsushima population of the genus. They also exhibited differences in scutellation and vertebral morphology especially when compared with *A. b. blomhoffii* from the mainland of Japan. Moreover, the present specimens were remarkably distinct from congeners from China and South Korea in body proportion and karyotype. Therefore, we here describe the Tsushima population of *Agkistrodon* as a new species.

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MATERIALS AND METHODS

Thirty-two specimens collected on Tsushima Island were examined immediately after being killed. They were morphologically compared with *A. b. blomhoffii*, *A. blomhoffii brevicaudus*, and *A. ussuriensis* on the basis of specimens and literature descriptions (Table 1). Specimens used for comparisons, obtained through commercial dealers, were: 98 *A. b. blomhoffii* from southern Kyushu, Japan; 63 *A. b. brevicaudus* from the lower basin of Changjiang (spelling of the pin-yin system), China; and 49 *A. ussuriensis* from Kangwon-do, South Korea. These species and subspecies have several characteristics common to the present species (i.e., occurrence of paired pits on dorsal scales, and 21 midbody scale rows; Gloyd and Conant, 1982), and hence are considered as its close relatives.

External characters used for comparisons were: body proportion, scutellation, body coloration, and dorsal and ventral patterns. The numbers of ventral and subcaudal scales were counted by the wider-than-long system. Alterations of dorsal scale rows were formulated following Dowling's (1951) method. Morphometric characters examined were: body mass (BM); head length (HL); head width (HW); total body length (TBL); snout-vent length (SVL); tail length (TL); and tail length in relation to total body length (RTL).

Also, considering variations in vertebral morphology within the *A. blomhoffii* complex (sensu Gloyd and Conant, 1990) demonstrated by Toriba (1988), the following measurements were taken for every tenth vertebra to the nearest 0.01 mm with digital calipers: overall height, ver-

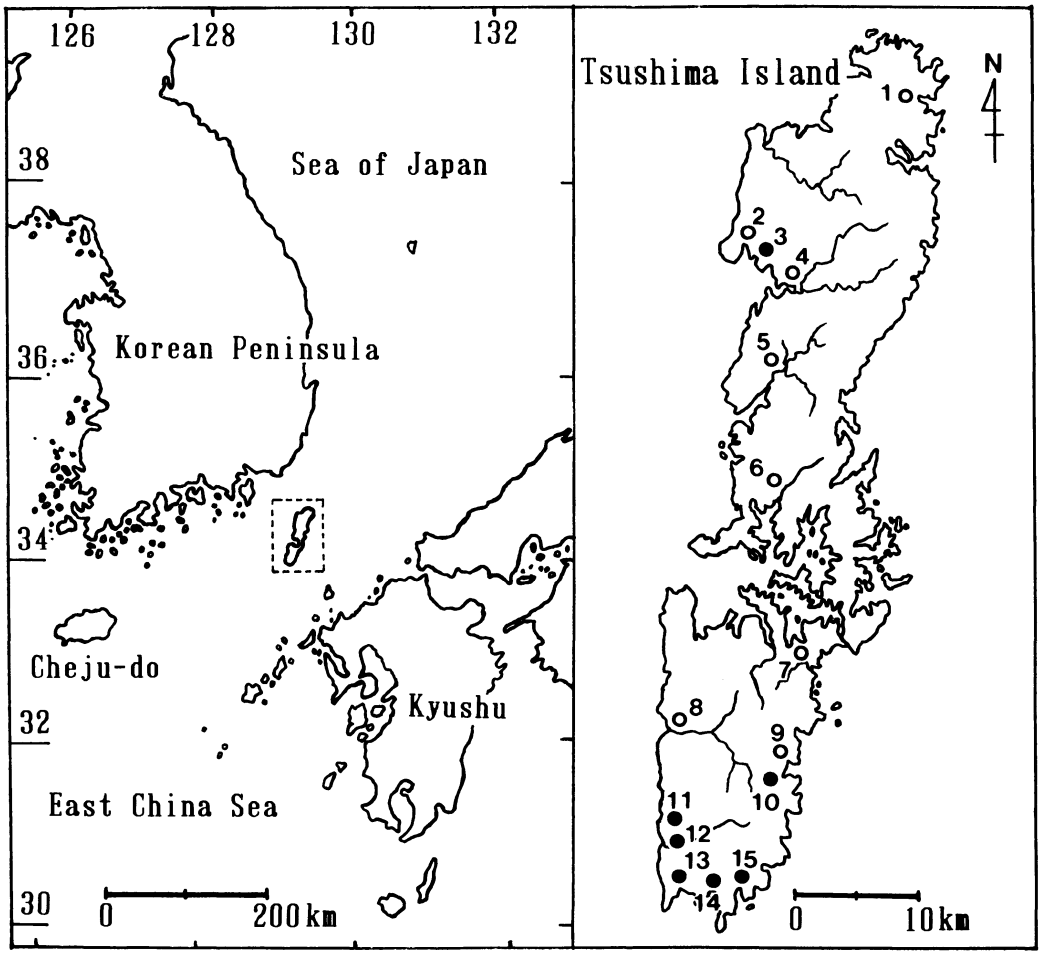

FIG. 1. Maps showing the geographic location of Tsushima Island and sampling localities of the specimens examined (closed circles). Locality names are as follows: 1, Hidakatsu; 2, Shitaru; 3, Ina; 4, Nita; 5, Mine; 6, Nii; 7, Kechi; 8, Komoda; 9, Izuhara; 10, Hotta; 11, Kunehama; 12, Sasuse; 13, Tsutsu; 14, Azamo; 15, Yora-Naiin (type locality).

tical distance from top of neural spine to tip of hypapophysis; overall length, horizontal distance between tips of prezygapophysis and postzygapophysis; neural spine height, vertical distance from upper margin of spinal foramen to top of spine; and neural spine length, distance from front to rear edges of neural spine. The numbers of specimens used for morphometric comparisons of vertebrae were six for the present species, five for *A. b. blomhoffii*, eight for *A. b. brevicaudus*, and seven for *A. ussuriensis*.

One male and one female of the present species were used for karyological study. Bone marrow cells from ribs were used and karyotype was determined on well spread metaphase cells following the method described by Yosida and Toriba (1986a).

Some of the values used for numerical comparisons were calculated from data given in the literature. Acronyms for catalogue numbers of the specimens are: OMNH, Osaka Museum of Natural History, Osaka; YMS, Yomeishu Seizo Co., Ltd Central Research Laboratories Kushikino Branch Lab., Kushikino.

Agkistrodon tsushimaensis sp. nov.
(Japanese name: Tsushima Mamushi)
(Fig. 2)

Ancistrodon blomhoffii: Boulenger, 1896, 525 (part).
Agkistrodon blomhoffii: Stejneger, 1907, 457 (part); Mori, 1929, 3 (part).
Agkistrodon halys blomhoffii: Maki, 1931, 203 (part); Koba, 1955, 346 (part).

TABLE 1. Localities of the species and subspecies of the genus *Agkistrodon* used for morphological comparisons. Data sources are also provided.

Species/Subspecies	Locality	Source
A. tsushimaensis	Tsushima Isl., Nagasaki Pref., Japan	Present study
A. blomhoffii blomhoffii	Southern Kyushu, Japan	Present study
	Japan	Maki (1931)
	Central Honshu, Japan	Toriba (1988)
A. blomhoffii brevicaudus	Lower Changjiang basin, China	Present study
	Korea and South Manchuria	Gloyd (1972)
	Changjiang basin, China	Gloyd (1977)[1)]
	Korea and China	Maki (1931)
	South Korea	Paik and Yang (1989)
	South Korea	Paik et al. (1979)
A. ussuriensis	Kangwon-do, South Korea	Present study
	Far Eastern region of Russia	Emelianov (1929)
	Korea and South Manchuria	Gloyd (1972)[2)]
	South Korea	Paik and Yang (1989)
	South Korea	Paik et al. (1979)
	South Korea	Toriba (1988)

[1)] *A. blomhoffii siniticus* in the original report.
[2)] *A. caliginosus* in the original report.

Agkistrodon halys: Goris, 1965, 12; Yamaguchi, 1966, 32 (part); Uéno and Shibata, 1970, 194; Urata and Yamaguchi, 1976, 259; Matsuo, 1989, 110 (part).
Agkistron halys: Ohno, 1968, 103 (part).
Agkistrodon blomhoffi blomhoffi: Hashimoto and Toriba, 1983, 50; Sengoku, 1987, 142.
Agkistrodon blomhoffii blomhoffii: Gloyd and Conant, 1990, 275 (part).

Holotype.—OMNH R3934, an adult male collected at Yora-Naiin, Izuhara-cho, Shimoagata-gun, Nagasaki Prefecture, Japan, on 28 July 1987 by the YMS Research Team. The specimen was found on the bank of a rice paddy along a mountain stream at night (ca. 20:00).

Paratypes.—OMNH R3935, an adult male from Tsutsuse, Izuhara-cho, on 28 July; OMNH R3936, an adult female, from Kunehama, Izuhara-cho, on 28 July; OMNH R3937, a juvenile female from Ina, Kamiagata-cho, Kamiagata-gun, on 30 July; OMNH R3938, an adult female from Azamo, Izuhara-cho, on 30 July; OMNH R3939–41, adult males from Azamo, on 30 July. All specimens were collected in 1987 during night surveys by the YMS Research Team.

Other specimens examined.—Azamo: YMS-610701, 620703–4, 620705 (skeleton and skin), 620706, 620713–14, 620716, 620718 (skeleton), 620719–20, 620723, 620724 (skeleton and skin); Hotta, Izuhara-cho: YMS-610705; Ina: YMS-610703, 610704 (skeleton and skin), 620712; Tsutsu, Izuhara-cho: YMS-610702; Tsutsuse: YMS-620708 (skeleton), 620709; Yora-Naiin: YMS-620702, 620725–26, 620727 (skeleton).

Etymology.—The name *tsushimaensis* refers to Tsushima Island, to which the range of the present species is confined.

Diagnosis.—This species differs from its relatives in the following combination of characters: pits on dorsal scales inconspicuous; ventrals 140–151 in males, 144–153 in females; subcaudals 44–50 in males, 38–45 in females; central dark spots lacking in dorsal blotches; number of bands on trunk 21–28; postocular streak poorly contrasted; venter with pepper-and-salt pattern consisting of numerous fine dark speckles, such pigmentation lacking in the distal half of tail; tongue pink or reddish brown in life; vertebra relatively depressed in shape, its neural spine considerably low, especially compared to that of *A. b. blomhoffii*; W of sex chromosomes subtelocentric.

Description of holotype.—Measurements are: BM = 106.3 g in life; TBL = 563 mm; SVL = 477 mm; TL = 86 mm; RTL = 15.3%; HL = 29 mm; HW = 20 mm.

Dorsal surface of head covered with nine symmetrically arranged scales (Fig. 2A). Internasals curving obliquely backward, tapering posteriorly. Prefrontals as wide as long, roundish on lateral edge. Frontal bell-shaped, somewhat pointed posteriorly. Supraoculars slightly convex, outside margin weakly curving inward above orbits. Parietals longer than wide, outside margin roundish, posterior edge weakly

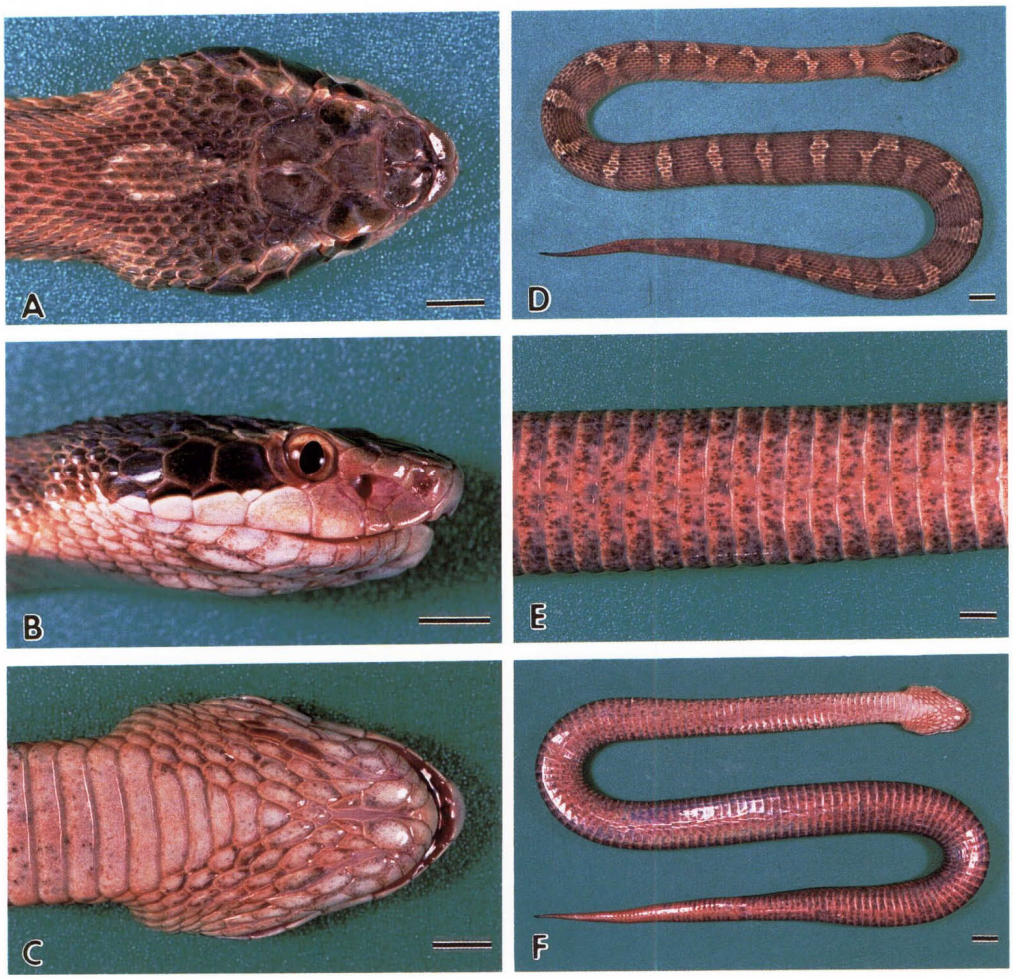

FIG. 2. Dorsal (A and D), lateral (B), and ventral views (C, E, and F) of the holotype of *Agkistrodon tsushimaensis* sp. nov. (OMNH R3934). Scale bars equal 5 mm in A, B, C, and E, and 10 mm in D and F.

zigzag.

Rostral broader basally, its surface slightly convex forward. Nasals divided, anterior element larger than posterior one. Loreal single, slightly longer than high, with obtuse apex in posterior end. Preoculars two, extending to front canthus; upper preocular twice as long as high, double the size of lower one; lower preocular much longer than high. Postoculars two; upper one small; lower one boomerang-shaped, extending along rear edge of orbit, contacting posterodorsal edge of third supralabial and anterodorsal edge of fourth supralabial just below eye. Temporals in two horizontal rows; upper row consisting of three small smooth scales; lower row consisting of three enlarged, hexagonal smooth scales, first one largest. Supralabials seven; second one smallest, contacting prefoveal and postfoveal dorsally below pit; third enlarged, highest, contacting orbit at dorsal tip; fourth almost equal to third one in size, but longer (Fig. 2B). Infralabials 10; first to fourth ones narrow, second smallest, sixth largest, ninth and tenth much longer than high; first infralabials tapering backward to pointed end, contacting each other between chin shields. Mental broader dorsally, tapering backward to pointed end on median line. Chin shields in one pair; each slightly longer than wide, distinctly enlarged as compared with surrounding scales, followed by two small median gulars (Fig. 2C).

Scales in middorsal region narrow, those in costal region broader and roundish; all dorsal scales from occipital region to tail keeled, more prominently in spinal region; paired apical pits

inconspicuous. Dorsal scale rows 21 at midbody, altering as follows:

$$26\ (10)\frac{-6\ (12)}{}\ 25\frac{5+6\ (17)}{5+6\ (17)}\ 23\frac{4+5\ (28)}{5+6\ (28)}$$

$$21\frac{4+5\ (108)}{4+5\ (105)}\ 19\frac{4+5\ (121)}{}\ 18\frac{4=4+5\ (124)}{4+5\ (124)}$$

$$18\frac{-4\ (126)}{+4\ (126)}\ 18\frac{+4\ (131)}{4+5\ (131)}\ 18\frac{-4\ (132)}{}$$

$$17\frac{4=4+5\ (136)}{}\ 18\frac{-4\ (138)}{}$$

$$17\frac{2=2+3\ (151)}{}\ 18\ (152)$$

Ventrals 152. Anal plate entire, similar to preceding ventrals in coloration. Subcaudals 48, each divided medially, making series of alternate sutures. Terminal scute sharply pointed.

Coloration in life.—Dorsal ground color brown, darker on head than on trunk and tail; parietals without lyriform figure, but with a small light spot on the median suture; waterdrop-like figure in the middle of occipital region (Fig. 2A). Dorsal pattern not very distinct, but consisting of two alternating rows of relatively enlarged, circular to nearly elliptical blotches outlined by dark margins of one or two scales' breadth; central dark spot lacking in each blotch; blotches of both sides frequently forming complete crossbands near midtrunk by fusing to each other medially; longitudinally neighboring blotches separated from each other by lighter interspace. The interspace of one to two scales' width, brownish yellow in ground color, with darker stippling (Fig. 2D). Contrast of the dorsal pattern weaker dorsolaterally, with gradual increase of flesh tint or pale pink coloration toward ventrals. Number of discernible bands 21 on right and 22 on left on trunk, five on each side on tail.

Ventral side of head pale creamy pink in ground color, with dark brown freckles on margin of each scale, especially prominent on lateral gulars (Fig. 2C). Ventrals creamy to whitish pink in ground color, with typical pepper-and-salt pattern consisting of numerous fine brown, gray, partly reddish brown speckles (Fig. 2E); such speckles almost lacking on first to sixth ventrals, sparse on breast, gradually becoming dense toward posterior abdomen with relatively heavy lateral stippling. Subcaudals on anterior half of tail reddish brown, with dark freckles; those on posterior portion more reddish with no freckles (Fig. 2F). Terminal scute of tail reddish brown on ventral side of base, dark brown on the other part.

Temporal stripe dark brown with indistinct light freckles; upper side bordered by inconspicuous light streak (postocular streak) ex-

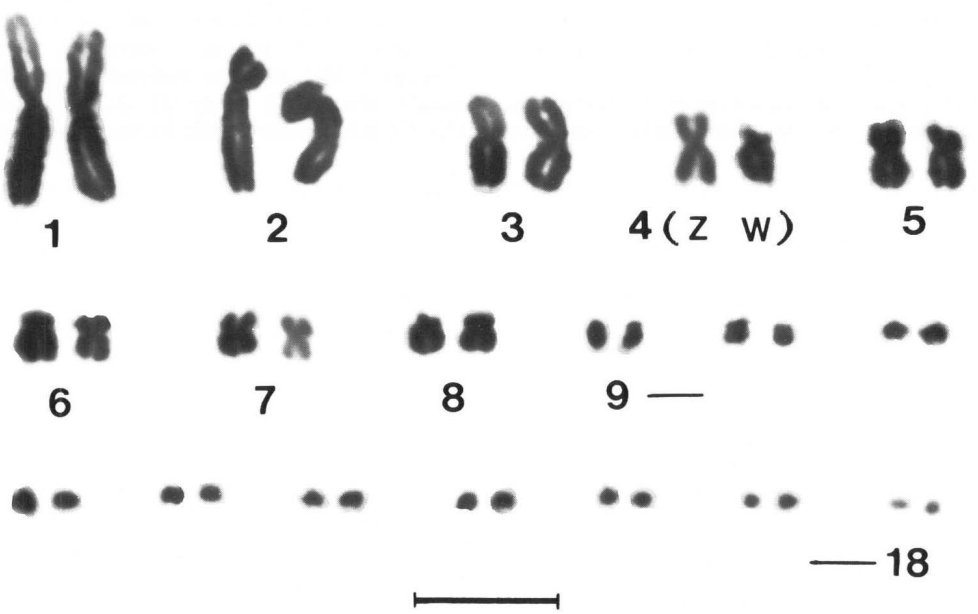

FIG. 3. Karyotype of a female *Agkistrodon tsushimaensis* sp. nov. Sex chromosomes (pair No. 4) are denoted by the letters Z and W. Scale bar equals 10 μm.

TABLE 2. Relative head lengths of *A. tsushimaensis* and its relatives. See the text for abbreviations. SD: standard deviation.

Species/Subspecies	N	HL/HW			HL/SVL (%)		
		Range	Mean	SD	Range	Mean	SD
A. tsushimaensis	32	1.30–1.77	1.46	0.11	5.1–6.6	5.9	0.36
A. b. blomhoffii	98	1.15–1.65	1.37	0.11	5.7–7.1	6.4	0.24
A. b. brevicaudus	32	1.36–1.79	1.52	0.15	4.8–7.7	6.1	0.47
A. ussuriensis	49	1.26–1.73	1.42	0.11	5.3–6.7	6.0	0.25

tending backward from outer margin of supraocular through upper postocular to last upper temporal, fading posteriorly with blurred contrast; lower side of the stripe with blackish margin, bordered below by sharp narrow white line extending obliquely backward from the end of lower postocular toward corner of mouth. Supralabials creamy in ground color, with fine brown freckles on their surfaces, more prominently on first to third supralabials. Infralabials similar to supralabials in ground color, but stippled on margin by dark speckles (Fig. 2B).

Tongue reddish brown with numerous fine whitish flecks medially, its slenderly bifurcated tips pinkish. Iris varicolored, its upper half yellowish brown zonally, lower half brown with yellowish dapples. Pupil vertically oval, blackish, with a fine bright edge (Fig. 2B).

Coloration after preservation.—Color of body faded, making color pattern nearly monochromatic and still more indistinct than in life. Tongue changing to dark gray. Iris dark, and pupil white.

Karyotype.—The karyotype of *A. tsushimaensis* consists of 2n=36 chromosomes, including eight pairs of macroelements and 10 pairs of microelements. In the female, chromosomes forming the fourth pair are heteromorphic, one metacentric and the other subtelocentric, whereas both of those forming the fourth pair in the male are homologous metacentric elements. Thus, the metacentric and subtelocentric chromosomes forming the fourth pair in the female are considered Z and W sex chromosomes, respectively (Fig. 3).

Size and form.—Morphometric data for *A. tsushimaensis* are summarized in Tables 2 and 3. This species is relatively slender in appearance. The largest male (YMS-620726, collected on 30 July 1987) measured 587 mm in TBL (505 mm SVL+82 mm TL), whereas the largest female (YMS-620724, collected on 30 July 1987) measured 620 mm in TBL (547 mm SVL+73 mm TL). RTL is greater in males than in females.

Variation.—Variations in the numbers of ventrals, subcaudals and dorsal bands are presented in Tables 4, 5 and 6, respectively. Other characters also vary as follows: supralabials usually seven, but rarely six (3.1%) or eight (3.1%); infralabials usually 10, but sometimes 11

TABLE 3. Ratios of tail lengths to total body lengths (RTL; in percent) in *A. tsushimaensis* and its relatives. SD: standard deviation.

Species/Subspecies	Male				Female				Source
	N	Range	Mean	SD	N	Range	Mean	SD	
A. tsushimaensis	14	14.0–17.5	15.5	1.0	17	11.8–14.3	13.2	0.8	Present study
A. b. blomhoffii	46	15.5–18.4	17.0	0.7	52	13.8–16.3	15.3	0.6	Present study
	8	14.8–19.4	16.1	1.5	1		13.9		Maki (1931)
		14.9–17.5	16.5			13.4–15.0			Toriba (1988)
A. b. brevicaudus	34	12.2–13.9	13.0	0.4	29	10.0–12.0	11.3	0.5	Present study
	16	12–15	13.5		18	11–13	11.7		Gloyd (1972)
		12.0–16.0	13.6			10.0–14.0	11.5		Gloyd (1977)
	6	10.2–16.4	14.0	2.2	6	10.2–16.2	12.6	2.5	Maki (1931)
	39	10–17	14.5		53	10–16	12.7		Paik et al. (1979)
A. ussuriensis	24	14.0–16.0	15.6	0.6	25	11.5–14.8	13.4	0.9	Present study
	14	11.6–17.4	14.8	1.4	18	12.1–14.7	13.5	0.6	Emelianov (1929)
	19	15–17	15.8		34	12–15	14.0		Gloyd (1972)
	52	8–16	13.8		57	11–16	13.2		Paik et al. (1979)

TABLE 4. Variation in the number of ventrals in *A. tsushimaensis* and its relatives. SD: standard deviation.

	Male				Female				
Species/Subspecies	N	Range	Mean	SD	N	Range	Mean	SD	Source
A. tsushimaensis	14	140–151	145.3	2.8	18	144–153	147.5	2.1	Present study
A. b. blomhoffii	46	138–145	141.0	1.7	52	137–146	141.9	1.9	Present study
	14	138–148	142.3	3.2	8	137–145	141.1	2.6	Maki (1931)
		135–141	138.2			140–145	141.4		Toriba (1988)
A. b. brevicaudus	34	136–143	139.6	1.9	29	138–144	140.9	2.0	Present study
	25	135–145	138.9	2.6	31	140–149	143.2	2.4	Gloyd (1972)
		132–146	139.1			134–148	141.4		Gloyd (1977)
	15	137–153	147.0	3.8	15	137–156	146.0	5.8	Maki (1931)
	47	137–158	142.6	4.5	75	135–165	144.3	4.1	Paik and Yang (1989)
	39	142–151	146.0	2.4	53	140–159	147.5	2.6	Paik et al. (1979)
A. ussuriensis	24	136–151	145.0	3.7	25	142–151	146.8	2.4	Present study
	14	146–152	149.5	2.1	18	149–157	153.2	2.4	Emelianov (1929)
	34	139–153	146.8	3.5	41	143–155	148.0	2.8	Gloyd (1972)
	5	140–148	145.3	2.9	21	143–154	148.1	3.3	Paik and Yang (1989)
	52	142–150	147.0	2.2	57	142–151	147.2	3.5	Paik et al. (1979)
		141–154	146.3			146–154	149.9		Toriba (1988)

(21.9%); dorsal pattern usually indistinct, but sometimes distinct; lyriform figure on parietals usually inconspicuous, but sometimes lacking; ground color varying from dark brown to light brown dorsally, creamy to whitish gray on ventrals, and reddish to yellowish on subcaudals. However, there are no variations in the numbers of midbody scale rows (21), preoculars (two) and postoculars (two). One adult female (YMS-610704) differed from the other specimens in exhibiting reddish brown dorsal ground color and whitish pink ground color with reddish brown freckles on venter in life.

Distribution.—Only on Tsushima Island, Nagasaki Prefecture, Japan.

Natural history.—*A. tsushimaensis* seems to be relatively fast-moving compared to *A. b. blomhoffii*, and is probably nocturnal during the summer (Urata and Yamaguchi, 1976), because all specimens were found during the night. The species feeds on field mice, small birds, and so on (Urata and Yamaguchi, 1976).

One adult female collected on 12 July 1986 and three collected on 30 July 1987 gave birth to four to six young ($\bar{x}=5.0$) in September of the respective year. These newborns (N=20) measured 4.3–7.7 ($\bar{x}=5.6$) g in BM, 198–232 ($\bar{x}=212$) mm in TBL, 172–195 ($\bar{x}=180$) mm in

TABLE 5. Variation in the number of subcaudals in *A. tsushimeansis* and its relatives. SD: standard deviation.

	Male				Female				
Species/Subspecies	N	Range	Mean	SD	N	Range	Mean	SD	Source
A. tsushimaensis	14	44–50	46.8	1.9	17	38–45	40.9	2.2	Present study
A. b. blomhoffii	46	47–56	51.3	2.0	52	41–50	46.5	2.0	Present study
	14	45–56	50.4	3.5	8	45–49	46.9	1.2	Maki (1931)
		50–55	51.7			42–45	43.6		Toriba (1988)
A. b. brevicaudus	34	36–42	38.5	1.7	29	30–37	33.6	1.9	Present study
	24	35–44	40.5	2.0	33	30–38	34.9	1.8	Gloyd (1972)
		33–43	39.0			28–37	33.3		Gloyd (1977)
	14	31–54	43.7	6.8	15	32–45	38.3	4.7	Maki (1931)
	45	27–45	38.4	2.3	75	31–43	35.6	2.9	Paik and Yang (1989)
	39	32–52	45.2	4.4	53	32–47	40.7	2.9	Paik et al. (1979)
A. ussuriensis	24	41–52	45.5	2.3	25	33–46	39.8	2.8	Present study
	14	37–51	45.9	3.4	18	39–47	42.6	2.2	Emelianov (1929)
	32	40–52	46.8	3.0	42	36–48	42.2	2.3	Gloyd (1972)
	5	38–43	39.8	1.9	21	34–48	38.8		Paik and Yang (1989)
	52	40–51	45.7	2.5	57	31–47	40.9	4.3	paik et al. (1979)
		42–48	45.0			38–48	41.9		Toriba (1988)

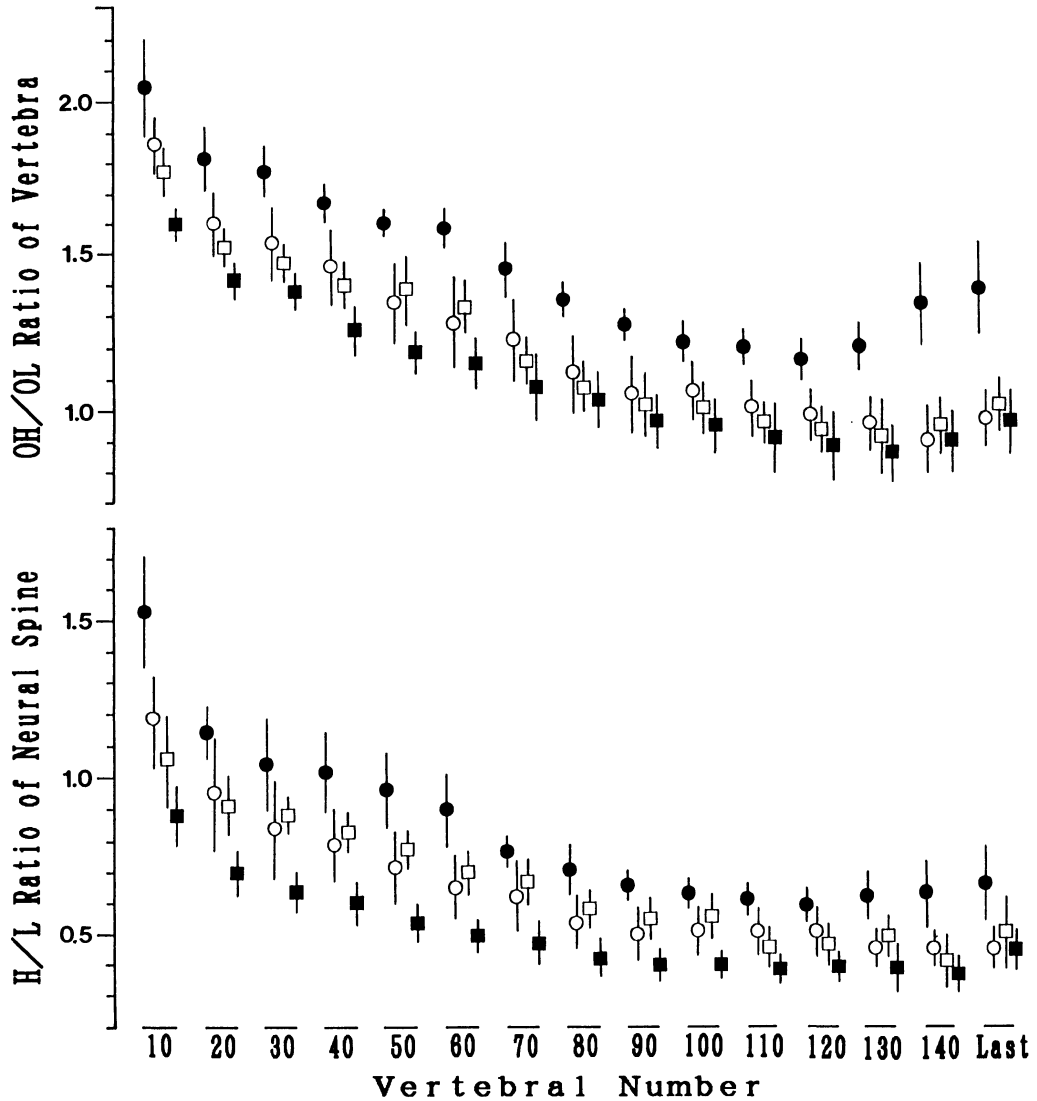

FIG. 4. Overall height (OH)/overall length (OL) ratio of vertebrae and height (H)/length (L) ratio of neural spines in *Agkistrodon tsushimaensis* sp. nov. (open circles: N=6), *Agkistrodon blomhoffii blomhoffii* (closed circles: N=5), *Agkistrodon blomhoffii brevicaudus* (open squares: N=8), and *Agkistrodon ussuriensis* (closed squares: N=7). Locations of symbols and vertical bars represent means and ranges of plus and minus standard deviations from means, respectively.

SVL, and 26–37 ($\bar{x}$=32) mm in TL, and ventral surfaces of their tail tips were faintly pinkish yellow.

Comparisons with other related species and subspecies

Body proportion.—Head of *A. tsushimaensis* is shorter and slenderer than that of *A. b. blomhoffii*, but is similar to those of *A. b. brevicaudus* and *A. ussuriensis* in shape (Table 2). In each sex, RTL in *A. tsushimaensis* is smaller than in *A. b. blomhoffii* and markedly greater than in *A. b. brevicaudus*, but is nearly equal to that in *A. ussuriensis* (Table 3). These indicate that the general body shape of *A. tsushimaensis* is intermediate between those of *A. b. blomhoffii* and *A. b. brevicaudus* and similar to that of *A. ussuriensis*.

Scutellation.—The ventral number in *A. tsushimaensis* is greater than in *A. b. blomhoffii*

TABLE 6. Variation in the number of dorsal bands on trunk in *A. tsushimaensis* and its relatives. SD: standard deviation.

	Male				Female				
Species/Subspecies	N	Range	Mean	SD	N	Range	Mean	SD	Source
A. tsushimaensis	14	21–26	23.4	1.6	18	21–28	24.9	1.9	Present study
A. b. blomhoffii	30	16–23	19.9	1.3	30	17–23	19.3	1.6	Present study
	6	18–20	19.5	0.8	1		19		Maki (1931)
A. b. brevicaudus	21	24–37	30.7	3.0	22	27–38	32.7	3.3	Present study
	24	23–33	28.9		32	25–36	30.8		Gloyd (1972)
		25–37	30.1			23–38	30.1		Gloyd (1977)
	6	27–29	28.0	0.9	6	26–28	26.8	0.8	Maki (1931)
A. ussuriensis	24	22–34	28.4	3.1	25	23–33	27.7	2.7	Present study
	25	23–33	27.6		41	22–31	27.4		Gloyd (1972)

and *A. b. brevicaudus*, whereas its subcaudal number is notably smaller than in *A. b. blomhoffii* and greater than in *A. b. brevicaudus*. These values for *A. tsushimaensis* are nearly equal to those for *A. ussuriensis* in each sex (Tables 4 and 5).

The apical pits of dorsal scales in *A. tsushimaensis* and *A. ussuriensis* are inconspicuous, whereas those in *A. b. blomhoffii* and *A. b. brevicaudus* are conspicuous.

Coloration.—The number of dorsal bands in *A. tsushimaensis* is greater than in *A. b. blomhoffii* and smaller than in *A. b. brevicaudus* and *A. ussuriensis* (Table 6). As is noted above, the dorsal pattern of *A. tsushimaensis* is relatively weak in contrast, consisting of relatively enlarged elliptical blotches occasionally forming complete crossbands, whereas that of *A. b. brevicaudus* is more distinct, usually consisting of smaller and more roundish blotches seldom forming transverse bands. In *A. b. blomhoffii*, the dorsal blotches are similar to those in *A. tsushimaensis* in shape, but the pattern is commonly more contrasty. On the other hand, *A. ussuriensis* has generally an even more indistinct dorsal pattern consisting of smaller circular or squarish blotches. There are, however, considerable geographic variations in the dorsal pattern of *A. ussuriensis*; in specimens from China and Russia, the dorsal pattern is usually indistinct, but sometimes distinct; and in Cheju-do (South Korea) specimens, the pattern is consistently as distinct as in *A. b. brevicaudus* (Toriba, priv. comm.). Most *A. b. blomhoffii* and some *A. ussuriensis* have a dark spot in each dorsal blotch (Toriba, 1988), whereas such a spot is consistently lacking in *A. tsushimaensis* as well as in *A. b. brevicaudus*.

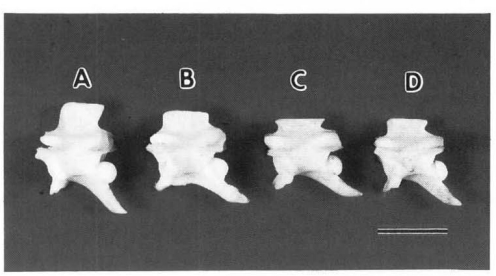

FIG. 5. Left lateral views of mid-trunk vertebrae of *Agkistrodon blomhoffii blomhoffii* (A), *Agkistrodon blomhoffii brevicaudus* (B), *Agkistrodon ussuriensis* (C), and *Agkistrodon tsushimaensis* sp. nov. (D). Scale bar equals 5 mm.

Ventral pattern also differs remarkably among these species and subspecies. *A. tsushimaensis* has a peculiar pepper-and-salt pattern on the ventral surface, whereas *A. b. blomhoffii* and *A. b. brevicaudus* have large, well developed dark speckles, making the ventral surface much darker. In *A. ussuriensis*, the ventral pattern is generally obscure, and the speckles are not so fine as those in *A. tsushimaensis*.

Large interspecific differences are also recognized in the coloration of the postocular streak and tongue. The postocular streak of *A. tsushimaensis* is inconspicuous and blurred, whereas that of the other three species and subspecies examined is sharp and bright yellowish or whitish as described by Gloyd (1972, 1977) and Toriba (1988). The tongue of *A. tsushimaensis* and *A. ussuriensis* is always pink or reddish brown, whereas that of *A. b. blomhoffii* and *A. b. brevicaudus* is invariably blackish.

Karyotype.—The karyotype of *A. tsushimaensis* seems to be identical with that of *A. b. blomhoffii* and *A. b. brevicaudus* described by Yosida and Toriba (1986a, b) at least at the Giemsa level. However, it seem to be distinct from

the karyotype of *A. ussuriensis* in the sex chromosome morphology, because the W-chromosome of the latter is reported to be telocentric (Yosida and Toriba, 1986b; Toriba, 1988).

Vertebral morphology.—The overall height/overall length ratio of the vertebra and the height/length ratio of the neural spine markedly differ in *A. tsushimaensis* and its relatives. These ratios in *A. tsushimaensis* are close to those in *A. b. brevicaudus*, but are much smaller than in *A. b. blomhoffii* and greater than in *A. ussuriensis* (Fig. 4). The general shape of the middle vertebrae of these four taxa is compared in Fig. 5. The degree of development of the neural spine and hypapophysis in *A. tsushimaensis* and *A. b. brevicaudus* is intermediate between that in *A. b. blomhoffii* and *A. ussuriensis*.

Remarks.—Comparison suggests that *A. tsushimaensis* is morphologically intermediate between *A. blomhoffii* and *A. ussuriensis*. However, further character analyses are needed to define the phylogenetic relationships between these species and *A. tsushimaensis* appropriately.

Key to the *Agkistrodon blomhoffii* complex

There are considerable differences among the four members of the *Agkistrodon blomhoffii* complex in external characters, on which this key depends.

1a. Tongue pink or reddish brown; paired apical pits of dorsal scales inconspicuous. ·····2

1b. Tongue dark brown or nearly black; paired apical pits of dorsal scales conspicuous. ·····3

2a. Dorsal blotches relatively large, usually elliptical, numbering 21–28 on trunk; small dark spots lacking in blotches; postocular streak poorly contrasted; ventral scales with pepper-and-salt pattern consisting of numerous fine speckles. ·····*A. tsushimaensis* sp. nov.

2b. Dorsal blotches relatively small, usually circular, sometimes squarish, numbering 22–34 on trunk; small dark spots in blotches usually lacking, but sometimes present; postocular streak sharp, bright yellowish or whitish; ventral scales dappled with ill defined dark speckles. ·····*A. ussuriensis*

3a. Tail long, 15–18% of TBL in males, 13–16% in females; dorsal blotches relatively large, usually elliptical, occasionally forming complete crossbands, numbering 16–23 on trunk; small dark spots commonly present in blotches; ventral side of tail tip in adults usually dark-colored; subcaudals 47–56 in males, 41–50 in females. ·····*A. blomhoffii blomhoffii*

3b. Tail short, 12–14% of TBL in males, 10–12% in females; dorsal blotches relatively small, generally roundish, seldom forming transverse bands, numbering 25–38 on trunk; dark spots lacking in blotches; ventral side of tail tip in adults usually yellowish; subcaudals 36–42 in males, 30–37 in females. ···*A. blomhoffii brevicaudus*

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要旨　長崎県対馬のマムシの新種としての記載

五十川清・守屋　明・三井貞明

長崎県対馬のマムシの形態を精査し，日本本土産のニホンマムシ (*Agkistrodon blomhoffii blomhoffii*)，中国産のタイリクマムシ (*A. blomhoffii brevicaudus*) 及び韓国産のウスリーマムシ (*A. ussuriensis*) と比較した．その結果，対馬のマムシはそれらとは形態的に著しく異なることがわかり，新種 (*Agkistrodon tsushimaensis* sp. nov. ツシママムシ) として記載された．また，この新種を含めた近縁種間の検索表を付記した．

（896 鹿児島県串木野市下名2248 養命酒製造㈱中央研究所串木野支所（五十川）・399–46 長野県上伊那郡箕輪町中箕輪2132–37 養命酒製造㈱中央研究所（守屋）・399–41 長野県駒ヶ根市赤穂16410 養命酒製造㈱駒ヶ根工場（三井））